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What are we saving? Developing a standardized approach for conservation action

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Abstract

Are all species equal in terms of conservation attention? We developed a novel framework to assess the level of conservation attention given to 697 threatened mammals and 100 critically endangered amphibian species. Our index of conservation attention provides a quantitative framework for assessing how conservation resources are allocated, based on the degree to which conservation interventions have been proposed and implemented. Our results provide evidence of the strong biases in global conservation attention. We find that most threatened species receive little or no conservation, and that the small number receiving substantial attention is extremely biased. Species most likely to receive conservation attention are those which are well-studied, charismatic and that live in the developed world. Conservation status and evolutionary distinctiveness appear to have little importance in conservation decision-making at the global scale. Most species inhabit the tropics and are both poorly known and uncharismatic. Therefore, the majority of biodiversity is being ignored by current conservation action.

Introduction

We may be winning small battles, but we are losing the war – and the future of biodiversity hangs precariously in the balance (Balmford & Cowling, 2006). Human-induced damage from population explosion and advances in technology and travel have resulted in unprecedented acceleration in the rate of species extinction. Invaluable genetic variation is being lost and entire biological communities are being destroyed due to a plethora of anthropogenic forces (Pimm *et al*., 1995; Lande, 1998; Brooks *et al*., 2006; Primack, 2006). Recent data suggest that current rates of extinction are now 1000 times higher than background levels, and that future extinction rates may be up to 100 times higher still (Pimm *et al*., 1995; Mace, Masundire & Baillie, 2005).

Faced with these escalating challenges, scientists continue to search for effective ways to identify priority areas and species for conservation. Conservation efforts involving threatened, endemic, restricted-range species, flagship, landscape, keystone or umbrella species, and species that are 'indicators' or culturally/economically important have all been proposed as short-cuts in setting conservation priorities (Vane-Wright, Humphries & Williams, 1991; Roberge & Angelstam, 2004; Mace, Possingham & Leader-Williams, 2006). These competing, and potentially conflicting, forces have resulted in an uncordinated and piecemeal approach to species conservation. This raises an important question for conservation: what have we chosen, in effect, to prioritize?

Worryingly, we are not well-placed to provide answers, since few data have been gathered on the kinds of species that have been selected as priorities (Groombridge, 1992; Balmford & Long, 1995). If we do not understand which species have been selected for concerted conservation attention, we are poorly equipped to offer prescriptions or plan effectively for future conservation initiatives (Balmford & Long, 1995; Redford *et al*., 2003). The few studies that do exist measure conservation attention in terms of the number of scientific papers devoted to an order (Amori & Gippoliti, 2000) or the number of reintroduction projects committed to a particular taxonomic group (Seddon, Soorae & Launay, 2005). There is currently no standardized framework for identifying conservation attention at the species level. Such systems are essential for our understanding of key conservation gaps and to mobilize the conservation community and direct conservation efforts more pragmatically (Clark & May, 2002).

In this paper we address this lacuna by proposing a classification system of conservation attention among species. We then apply the technique to hundreds of threatened vertebrates in order to identify gaps in conservation action, and examine the traits of species that are receiving most conservation attention and those that are being overlooked. Specifically, we explore the relationship between conservation attention and the following variables: taxonomic group, biogeographic region, threat status, body size, charismatic appeal, scientific knowledge and evolutionary distinctiveness.

This paper provides a foundation for a standardized and comparable approach for categorizing past, present and future conservation attention. We anticipate that the approach will be developed and enhanced as more data become available. Moreover, we hope it will enable scientists and decision makers to monitor conservation attention more effectively through time and to identify and address gaps where conservation is lacking.

Methods

Establishing an index of conservation attention (ICA)

Our ICA is based upon the level of conservation activities that have been proposed, developed and/or implemented, as described in Conservation Action Plans and other sources of literature. We determined the status of species by consulting journal articles, books, the IUCN Red List (IUCN, 2007), grey literature (including literature produced by the IUCN Specialist Groups, conference and workshop proceedings) and internet websites (including information derived from searches using Google, Google Scholar and Zoological Record). These data were compiled from over 4000 sources for 697 threatened mammals (IUCN, 2007) and 100 critically endangered amphibians (IUCN, Conservation International and NatureServe, 2006) between July and August 2007. Full details are presented in the supporting information (Appendix S1) along with justification for each assignment to a category of conservation attention.

Species considered to be receiving little or no conservation attention (ICA = 0) have not been included in an action plan, nor subject to any conservation research (either published or online). Species considered to be receiving high levels of conservation attention (ICA = 3) have a comprehensive and up to date action plan, at least some of the action plan has been implemented. Comprehensive action plans were defined as those covering a large part of the species' range, containing relevant information on species ecology, threat status, distribution, threatening processes, as well as proposed interventions to alleviate these threats (including habitat conservation and institutional support) and timescales over which specific outcomes would be achieved. Allocation of species in the intermediate categories was harder to define. Species considered to be in receipt of moderate levels of conservation (ICA = 2) are those that meet some, but not all, of the criteria above (e.g. if the action plan was over 10 years old). In addition, species fall into this category if they have been the subject of detailed conservation research that has yet to be incorporated into a species specific action plan, or if the species has benefited from a dedicated protected area with habitat-based conservation initiatives. Species deemed to be in receipt of low levels of conservation attention (ICA = 1) include those with action plans that are neither comprehensive nor up-to-date, species mentioned briefly in multi-species action plans but for whom no specific actions were recommended, and species for which little conservation-relevant research has been conducted.

Data sources

Our sample of mammals included all critically endangered (CR) species ($n = 149$), all endangered (EN; $n = 157$) and vulnerable (VU; $n = 291$) species whose Evolutionary Distinctiveness (ED) score (Isaac *et al.*, 2007) is above the median, as well as a stratified random sample of EN and VU species from below the median ED ($n = 45$ and 55, respectively). ED scores are based on species' phylogenetic position (following Bininda-Emonds *et al.*, 2007): species with few close relatives and those on long branches have higher scores than species in diverse clades. We selected a random sample of CR amphibian species, stratified by ED score (50 below and 50 above the median: N. J. B. Isaac & H. Meredith, unpubl. data) and by biogeographic region.

We classified species according to whether they were listed as declining populations (IUCN Criterion A), small populations (Criteria B–D) or both. Biogeographic regions were assigned using the World Wide Fund for Nature classification scheme (Olson *et al.*, 2001). Species occurring in multiple regions were assigned to the region which constituted the largest portion of the range.

We measured charismatic appeal and the level of knowledge for each species using the internet search engine Google and the Zoological Record database of scientific publications. For mammals, we measured charismatic appeal as the number of Google hits for each species' common name, and scientific knowledge as the number of articles on Zoological Record for the Latin name. For amphibians, we used the number of Google hits for each Latin name as a composite measure of charismatic appeal and scientific knowledge (few amphibians have English common names).

Mammalian body weights came from Bielby *et al.* (2007, $n = 42$ species) and Silva & Downing (1995). For data in Silva & Downing (1995), we preferred data on females over males, and preferred point estimates over midranges. For species not listed in these two sources, we used the mean mass of congeneric ($n = 316$) or confamilial ($n = 94$) species in Silva & Downing (1995).

Statistical tests

We sought statistical associations between ICA and each of our predictor variables using general linear models with Poisson errors. All continuous predictor variables (body weight, ED and Google hits) were log transformed prior to analysis. We used standard model criticism to validate this approach. We conducted first bivariate then multivariate models, sequentially removing nonsignificant terms and merging factor levels to generate a Minimum Adequate Model (MAM). Separate MAMs were created for mammals and amphibians.

We guarded against possible collinearity by measuring the correlation between predictor variables (supporting information, Appendix S2). In mammals, body size, charismatic appeal (Google hits) and scientific knowledge (articles on Zoological Record) are all positively correlated (Spearman's rank test: $0.49 \leq \rho \leq 0.56$). All other correlations are weak ($\rho \leq 0.3$).

Our four-point Index of Conservation Attention is potentially subjective when distinguishing between species receiving intermediate levels of conservation. Therefore, we explored the effect of merging 'low' and 'moderate' categories into a single 'intermediate' category of conservation attention, and repeated our analyses using this three-point scale.

Results

Six hundred and ninety-seven threatened mammals and 100 amphibians were assessed and assigned an ICA score. These data indicate that most of these threatened species receive little or no conservation (Fig. 1): the mean score was 0.81 for mammals and 0.29 for amphibians.

Mammals

Bivariate models revealed that all our candidate variables are correlated with ICA in mammals. Mammals are more likely to receive conservation if they are well-known, charismatic, more highly threatened, in decline, large-bodied and evolutionarily distinct (Table 1). We also found significant differences among Orders and Biogeographic Regions. Similar patterns are evident in the multivariate analysis, although body mass, evolutionary distinctiveness and Google hits are not significant, nor is the difference between small and declining populations (Table 1). In addition, there is no significant difference between CR and EN mammals ($\chi^2_1 = 1.48$, $P = 0.22$), although both receive more conservation attention than VU species (Fig. 2). The MAM also reveals how conservation attention is distributed among taxonomic groups and regions. Conservation attention is high in the Australasian and Nearctic regions and low in all others (Fig. 2). The taxonomic groups receiving most conservation attention are artiodactyls, perissodactyls and dasyuromorphs, while didelphimorphs and insectivores receive the least (Fig. 2). Qualitatively identical results are obtained when ICA is measured on a three-point scale (supporting information, Appendix S3).

Amphibians

Bivariate models revealed that all our candidate variables are correlated with ICA in amphibians. Critically endangered amphibian species are more likely to receive conservation if they are well-known and evolutionarily distinct. We also found significant differences among Families and Biogeographic regions. Although we found no difference ($\chi^2_1 = 0.05$, $P > 0.8$) between species listed on the basis of rapid population decline (IUCN criterion A) and small population size (criteria B–D), we did find that species listed as both small and in decline were more likely to receive conservation attention ($\chi^2_1 = 7.83$, $P = 0.005$). The difference among Red List criteria was not significant in the MAM, nor was there any significant difference among Families. However, the effects of Google hits, evolutionary distinctiveness and region remain important (Table 2). Among regions, we find that conservation attention is highest in Australasia, lowest in the Afrotropical and Indomalayan regions and intermediate elsewhere. Qualitatively identical results are obtained when ICA is measured on a three-point scale (supporting information, Appendix S3).

Discussion

This paper describes a systematic Index of Conservation Attention for assessing current conservation priorities and gaps at the species level. Our data reveal that the vast majority of mammals and amphibians threatened with

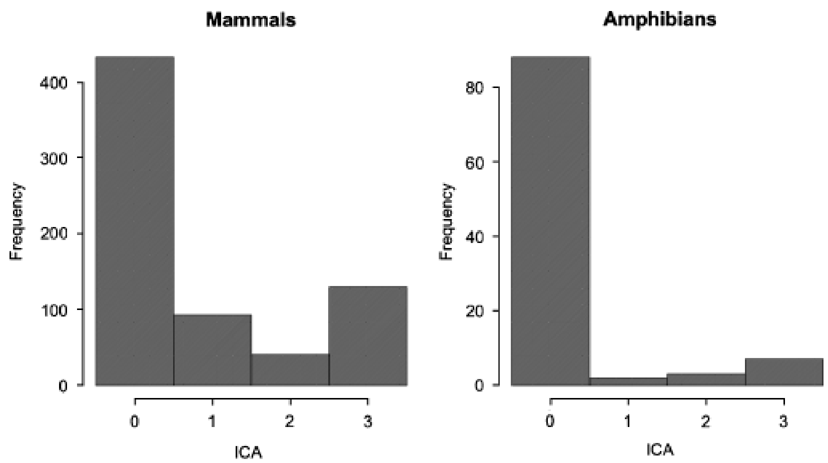

Figure 1 Histogram of index of conservation attention scores for mammals (n=697 species) and amphibians (n=100).

Table 1 Table showing the factors associated with ICA in Mammals

	Bivariate			Minimum Adequate Model (MAM)		
	χ^2	d.f.	P	χ^2	d.f.	P
Order	454	23	<0.0001	68.4	3	<0.0001
Biogeographic Region	140	7	<0.0001	71.0	1	<0.0001
IUCN Red List Category	18.4	2	0.0001	9.57	1	0.002
Declining versus small populations	87.8	2	<0.0001	0.97	2	0.61
Log(body mass)	274	1	<0.0001	0.06	1	0.80
Log(evolutionary distinctiveness)	75.3	1	<0.0001	2.26	1	0.13
Log(Google hits)	362	1	<0.0001	2.26	1	0.13
Log(articles on Zoological Record)	491	1	<0.0001	234	1	<0.0001

Values indicate the χ^2, degrees of freedom and *P*-value associated with removing each term from the model. Categorical variables use differing degrees of freedom due to merging factor levels in the MAM.
ICA, index of conservation attention; MAM, Minimum Adequate Model.

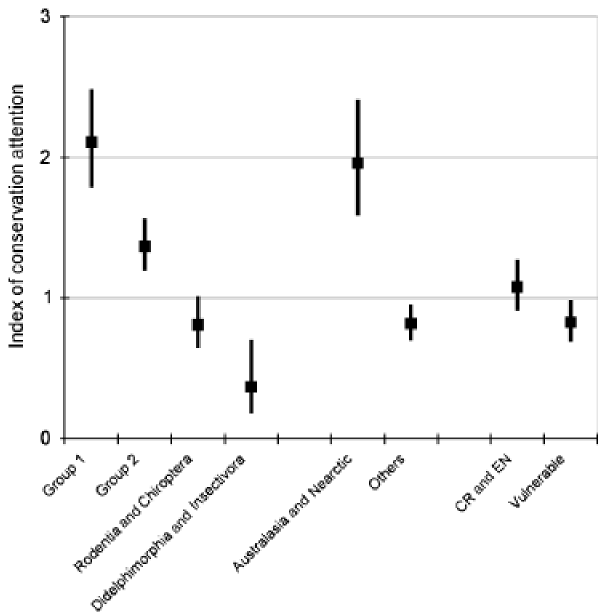

Figure 2 Effect sizes for Biogeographic Region (on the left), IUCN category and taxonomic order (right) in the Minimum Adequate Model for mammalian conservation effort. Square symbols indicate the magnitude of each effect (i.e. the fitted ICA when all other factors are held constant at their mean values) and vertical bars delimit the 95% confidence intervals. Group 1 consists of the Artiodactyla, Perissodactyla and Dasyuromorpha; Group 2 includes Carnivora, Cetacea, Diprodontia, Lagomorpha, Primates and 12 Orders that are represented by fewer than 10 species each.

extinction are receiving little to no conservation. Of the species assessed, 75% of threatened mammals and 90% of threatened amphibians scored zero or one on our index (Fig. 1). We suspect that the equivalent figures for reptiles, fish and invertebrates are higher still. This result suggests that very few threatened species are receiving well-planned, regularly monitored and updated conservation interventions.

Our results revealed strong biases in the species currently receiving conservation attention. In both mammals and amphibians, we find that conservationists tend to prioritize well-studied and/or charismatic species. In mammals, the number of articles on Zoological Record explains over 40% of the variance in ICA and the number of Google hits explains over 30%; in amphibians, the number of Google hits explains 44% of the variance in ICA. These relationships are sufficiently strong that Google (or Zoological Record) hits might be a reasonable shortcut method for comparing conservation attention across very large numbers of species. However, it is difficult to write an action plan for species that are poorly known, so a relationship between scientific knowledge and conservation is perhaps not surprising. However, two results from the mammals highlight the disproportionate attention given to charismatic megafauna. First, the large-bodied charismatic Orders (Artiodactyla, Carnivora, Perissodactyla and Primates) all lie near the top of the ICA scale (Fig. 2). Second, body mass remains highly significant in the MAM if taxonomic order is not included ($\chi^2_1 = 19.2$, $P < 0.0001$). Conservation of small mammals is low on the environmental agenda, in spite of the important roles they play in ecosystem function (Amori & Gippoliti, 2000, 2001; Entwistle & Dunstone, 2000). Our results are consistent with earlier studies which demonstrate that large-bodied mammals are disproportionately represented in captive breeding programmes (Balmford, Mace & Leader-Williams, 1996), reintroduction projects (Seddon *et al*., 2005), as flagship species (Clucas, McHugh & Caro, 2008) and on IUCN specialist groups and similar organizations (Magin *et al*., 1994). These findings confirm the perception that many conservation choices are made on subjective grounds, not scientific ones (Kellert, 1985; Metrick & Weitzman, 1996). In part, this is because the general public favours species they consider endearing or valuable, so conservation organizations base their fundraising effort around these kinds of species (Kellert, 1985; Entwistle & Dunstone, 2000; Mace *et al*., 2006). The flagship approach to conservation is therefore understandable, but does not always convey wide-ranging benefits to biodiversity and arguably diverts resources away from species of greater value or conservation need (Kerr, 1997; Andelman & Fagan, 2000; Linnell, Swenson & Andersen, 2000; Clucas *et al*., 2008).

Table 2 Table showing the factors associated with ICA in Amphibians

	Bivariate			Minimum Adequate Model (MAM)		
	χ^2	d.f.	*P*	χ^2	d.f.	*P*
Family	94.5	26	< 0.0001	26.3	26	0.45
Biogeographic Region	70.3	4	< 0.0001	99.6	3	< 0.0001
Declining versus small populations	9.79	2	0.0075	0.95	2	0.62
Log(evolutionary distinctiveness)	25.2	1	< 0.0001	10.2	1	0.0014
Log(scientific name hits on Google)	56.1	1	< 0.0001	17.8	1	< 0.0001

Values indicate the χ^2, degrees of freedom and *P*-value associated with removing each term from the model. Categorical variables use differing degrees of freedom due to merging factor levels in the MAM.
ICA, index of conservation attention.

The other effect that is consistent across both classes is the bias with respect to biogeographic region. Threatened species inhabiting the Australasian and Nearctic regions are especially likely to receive conservation (none of the four CR Nearctic amphibians were in our sample). Tropical and Palearctic species receive the least attention, and among amphibians the afrotropical region is particularly ignored. This result reflects the larger number of scientists and professional conservationists, as well as the higher funding levels that are available in the developed world (Gaston & May, 1992). Our finding that threatened species in tropical regions are least likely to receive conservation is extremely worrying: not only do these regions hold high levels of biodiversity, species found here are also on average at a greater risk of extinction (Grenyer *et al*., 2006; IUCN, 2007). The bias can only be rectified through both greater awareness of the conservation gaps and the diversion of funding for biodiversity conservation by governments in developed countries toward projects in the developing world.

Our results revealed weak associations between species status on the IUCN Red List and their chances of receiving conservation. Our MAM of mammalian conservation attention revealed no difference between endangered and critically endangered species, but species in both categories are more likely to receive conservation than species in the vulnerable category. This result is encouraging and suggests a conservation response to a perceived need. We predict that this relationship would become stronger were conservation attention to be assessed for lower risk species. However, we found no consistent differences between declining and small populations: different patterns were evident in mammals and amphibians, and neither relationship was significant once other factors were controlled (i.e. in the MAM).

We found that evolutionary distinct amphibians do tend to receive more conservation, but that there is no relationship in mammals once other factors have been considered (i.e. in the MAM). The difference between major groups perhaps reflects the fact that mammals are chosen for conservation on the basis of charismatic appeal, whereas amphibians are chosen because they are unusual. Put another way, the charismatic amphibian species tend to be evolutionarily distinct rather than large-bodied. This coincidence is a small piece of good news in the overwhelming crisis facing amphibian conservation (IUCN, Conservation International and NatureServe, 2006). However, the mammalian result is troubling, because extinction is non-random and whole clades are being pruned from the tree of life (Purvis & Hector, 2000; Purvis *et al*., 2000), leading to a dramatic reduction in overall genetic diversity (Krajewski, 1991). Evolutionarily distinct species that are large-bodied and charismatic, such as elephants, rhinos and orang-utans, receive high levels of conservation attention, but the majority of evolutionarily distinct species are small and/or nocturnal, and receive little or no conservation attention (Zoological Society of London, 2008). This will unlikely be rectified until our values change and evolutionary distinctiveness is better incorporated into conservation priority setting.

Our ICA is a flexible tool that could be applied to a wide range of organisms. The results of our analyses reveal that ICA is an efficient tool for exploring the allocation of conservation resources at the global scale. However, it is relatively coarse, in that it is based on species action plans, research findings and internet websites. It is inevitable that local-scale projects and those with unpublished results have been overlooked. We would welcome a global database of conservation initiatives in order to refine the index and build a more complete picture of global conservation efforts. However, even with this additional information, it would be difficult to estimate the effect to species of living inside protected areas (Andam *et al*., 2008), or the wider benefits of conservation interventions to non-target species. Further research to address this challenge would therefore be timely. Finally, our data provide a baseline against which future changes in conservation effort can be monitored over time and compared across different regions of the globe, thus contributing to the effective allocation of limited conservation resources (James, Gaston & Balmford, 1999).

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Resources and data used to apply the Index of Conservation.
Appendix S2. Spearman Rank Correlations among the predictor variables.
Appendix S3. Models of ICA based on a three-point scale

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